Water Uptake of Composite Membranes used in Elevated Temperature PEM Fuel Cells

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Proton exchange menbrane fuel cells (PEMFCs) show promise as energy conversion devices for portable, electric vehicle, and residential applications. Several fuel supply systems are being considered, but hydrogen via the reformation of a hydrocarbon is the leading candidate for commercialization.

Operation of PEMFCs above 100°C and at atmospheric pressure reduces CO poisoning from reformed fuels, prevents flooding at electrodes and improves system efficiency due to the recovery of heat.

To enhance the proton conductivity of the polymer electrolyte at high temperature and low humidity, proton conductors such as phosphotungtric acid[1] and zirconium hydrogen phosphate[2] are impregnated into Nafion®. Polarization studies of MEAs made from these composite membranes show that the performance at low humidity is enhanced due to the presence of the proton conductors which lower the IR resistance of the membrane and provide protons for the oxygen reduction reaction. The mechanism of proton conduction in the composite membrane related to the water uptake of composite membranes as a function of humidity at temperatures above 100°C.

In most previous studies, water uptake was determined by direct weighing of the membranes after equilibration in known humidity environments[3)-6)]. Unfortunately, at elevated temperatures (above the boiling point of water) the weighing technique is not conducive for accurate measurement. A new method was developed to monitor water uptake of the membrane using a conventional single fuel cell. The membrane with or without electrodes bonded to the membrane was placed in the single cell hardware (Electrochem, Inc.) without gas diffusion layers. A thermal conductivity detector (TCD) was connected to both outlets of the single cell. Helium at various relative humidities was supplied to both inlets of the cell. Typical experiments initially have dry helium fed at the cell temperature followed by a step change to the desired humidity. The water content of the exhaust gas from the cell is measured as a function of time. This allows the water uptake of the membrane to be calculated.

Fig.1 shows the typical TCD response when the gas supply was changed from that without moisture to that with moisture. The difference in area between an experiment without the membrane and with the membrane corresponds to the water amount absorbed into the membrane.

A comparison between the traditional weighing technique and this new technique will be presented for Nafion-like membranes with and without additives at temperatures less than 80°C. For temperatures greater than 80°C data will be presented using only this new technique.

Fig.2 shows water uptake of Nafion 117 at 80°C. The data obtained from this measurement agrees with the data by Hinatsu et al.[3)].

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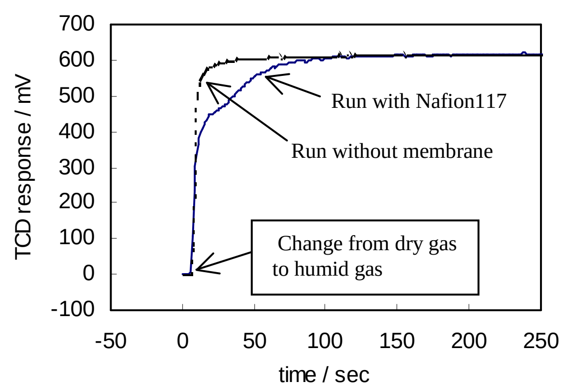

Fig.1 A TCD response during the water uptake measurement of Nafion117.

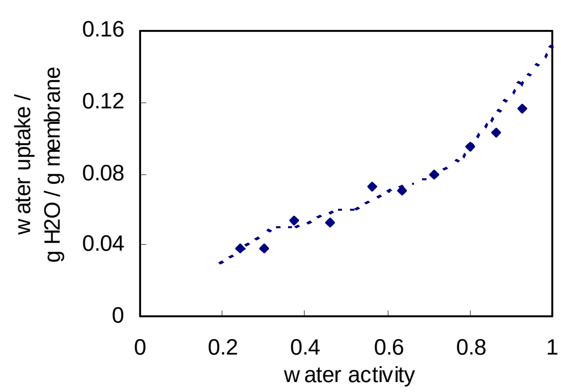

Fig.2 Water uptake of Nafion117 at 80°C. Filled diamonds plots were obtained from this work. Dashed line was obtained by Hinatsu et al.[3)].